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LIFE CYCLE INVOLVING BIRD-BIRD RELATION IN SARCOCYSTIS COCCIDIA WITH THE DESCRIPTION OF SARCOCYSTIS ACCIPITRIS SP. N.

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Abstract. The life cycle of a coccidium of the genus *Sarcocystis* realized in the relation bird-bird is described. The goshawk (*Accipiter gentilis*) served as the definitive host and shed oocysts of the size 21—25 × 15—17 μm, with relatively wide sporocysts slightly tapered at tips and measuring 15—17 × 13—15 μm. The canary (*Serinus canaria*) served as the intermediate host under experimental conditions. It is supposed that other species of *Passeriformes* serving as the food for the goshawk may become the intermediate hosts in nature. The sarcocysts inside the intermediate host had a very thin wall (< 1 μm) and were tapered and elongate (length in longitudinal sections about 600—900 μm, width in transverse sections 21—42 × 19—30 μm). The cystozoites were very small, crescent-shaped, and measured 5—7 × 1.5—2 μm. The species was named *Sarcocystis accipitris* sp. n. after its definitive host.

Until the present time, about 100 species of Sarcocystis have been described, but the two-host life cycle has only been deciphered in about one third of these heteroxenous coccidia. Mostly life cycles of Sarcosporidia involving carnivorous mammals (including man) as definitive hosts (Levine and Tadros 1980) have been described. Papers on this topic were also published by Box and Duszynski (1978, 1980), Box and Smith (1982), Box et al. (1984) and Duszynski and Box (1978). They dealt with the life cycle of *Sarcocystis falcatula* utilizing different members of three avian orders as intermediate hosts and the opossum as the definitive host. In a review paper by Černá (1984), birds were reported as definitive hosts and small mammals as intermediate hosts of various *Sarcocystis* species. The present paper gives new facts of the *Sarcocystis* life cycle involving predatory birds as definitive hosts and passerine birds as intermediate hosts of one species of this genus.

MATERIALS AND METHODS

Oocysts-sporocysts of *Sarcocystis* type were harvested from the intestines of two goshawks (*Accipiter gentilis*) obtained from a taxidermist workshop DIPRA, Prague. The material from *Accipiter nisus* used in a simultaneous experiment originated from the same workshop.

In the first stage of experiments; the sporocysts from the goshawks were fed to four 14-day-old chicken coming from a hen incubator. Chickens K_{1-2} were infected with the dose of about $6 . 10^5$ sporocysts from *Accipiter gentilis* 1 (Acc. g. 1) and chickens K_{3-4} with the same dose from *Accipiter gentilis* 2 (Acc. g. 2). At the same time, similar doses of sporocysts were fed to four laboratory SPF mice. The control was made three months after infection, when the muscles from all experimental animals were homogenized by the methods described in a previous paper (Černá and Merhautová 1981), and the sediment was examined for the presence of cystozoites or sarcocysts fragments.

In the second stage of experiments, canaries (*Serinus canaria*) were used as recipients of sporocysts from goshawks. The canaries at the age of about six months were bred under conditions preventing any contamination with faeces of predatory or other carnivorous birds. The sporocysts were fed to the canaries in the doses of $5 . 10^5$ sporocysts per bird. Two canaries (Se_{1-2}) were infected with sporocysts from Acc. g. 1 and the other two (Se_{3-4}) with sporocysts from Acc. g. 2.

The canary Se_1 died on day 17 after inoculation. Imprints were made from various organs (liver, lungs, brain, heart, skeletal muscles) and examined after Giemsa staining. The organs were processed also by histological methods and the sections were examined after staining with

Harris's haematoxyline. The other canaries (Se_{2-4}) were killed three months after feeding with sporocysts and the infection was observed after muscle homogenization on the one hand and after histological processing of muscles on the other hand.

Three canaries (Se_{5-7}) were fed with morphologically different sporocysts from *Accipiter nisus* (Acc. n.) in the dose of $5 \cdot 10^5$ per bird. They were examined three months after infection, like the canaries Se_{2-4}.

RESULTS

I. General results of inoculation experiments

After infection with the sporocysts from the goshawks (Acc. g. 1 and 2), no parasite reproduction or sarcocyst formation could be demonstrated in the muscles of any of the chickens (K_{1-4}) or mice (M_{1-4}) (Table 1). In the experiments with canaries, the birds Se_{5-7}, which were fed with the sporocysts from *Accipiter nisus* measuring 13—14.5 × 10 to 11 μm, remained uninfected (Plate I, Fig. 2, 3). Sarcocysts were found in the canaries Se_{2-4} fed with sporocysts from Acc. g. 1 and 2 (see later). An exception was the canary Se_1, which died on day 17 after inoculation and in which no reproductive stages of sarcosporidia could be demonstrated either in inner organs or in skeletal muscles.

II. Developmental stages of *Sarcocystis* from the goshawk-canary cycle

1. Oocysts and sporocysts from *Accipiter gentilis* 1 and 2

Two- sporocyst sporulated oocysts from the intestines of goshawks measured 21 to 25 × 15—17 μm (Plate I, Fig. 1).

The sporocysts were relatively wide, only slightly tapered at tips, and measured 15—17 × 13—15 μm.

2. Cyst stages from canaries (*Serinus canaria*)

Cystozoites

Very subtle, crescent-shaped cystozoites measuring 5—7.5 × 1.5—2 μm were found in the homogenates from skeletal muscles (Plate II, Fig. 2). They were stained with Giemsa. Their nucleus was situated more closely to the narrower tip and their plasma was light blue.

Table 1. Results of inoculation of chickens, canaries and mice with sporocysts from *Accipiter gentilis* (Acc. g.) and *Accipiter nisus* (Acc. n.)

Sporocysts from	Recipient	Control of muscle homogenate from recipient 3 months after infection
Acc. g. 1	Se_1	not done
	Se_2	+
Acc. g. 2	Se_3	+
	Se_4	+
Acc. n.	Se_5	neg
	Se_6	neg
	Se_7	neg
Acc. g. 1	K_1	neg
	K_2	neg
	M_1	neg
	M_2	neg
Acc. g. 2	K_3	neg
	K_4	neg
	M_3	neg
	M_4	neg

Explanations: Se = canary (*Serinus canaria*), M = mouse, K = chicken, + = cystozoites were found in muscle homogenate, neg = no cystozoites were found in muscle homogenate.

Sarcocysts

The sarcocysts were found in both longitudinal and transverse sections through the skeletal muscles of canaries and single sarcocysts occurred also in the heart. Transverse sections through the sarcocysts measured 21—42 × 19—30 μm (Plate I, Fig. 4, Plate II, Fig. 1). The longitudinal sections through the sarcocysts measured about 600—900 μm (Plate II, Fig. 3). The sarcocysts were thin, elongate and with a very thin wall (less than 1 μm) (Plate I, Fig. 4), in which no characteristic structure could be discerned in the optical microscope.

DISCUSSION AND CONCLUSIONS

As it was mentioned in the introduction, there is a large number of *Sarcocystis* species in which the intermediate host — definitive host relationship has not yet been studied. It is known that the birds may play a role of both intermediate and definitive hosts in *Sarcocystis* reproduction (Černá 1984), but no reports are available about birds playing the role of both two hosts in the life cycle of a particular species. In Ashford's (1975) opinion, there may be a relationship between "*Isospora buteonis*" oocysts shed by *Accipiter nisus* and cysts from muscles of *Serinus canaria*, but the author did not study this problem in detail. Many papers reported on cyst stages of sarcosporidia from muscles of birds belonging to various orders and families (Kalyakin and Zasukhin 1975, Todd et al. 1975, Drouin and Mahrt 1979) and canines (see, e.g., Wenzel et al. 1982), or opossums (Box and Duszynski 1980) were found to serve as definitive hosts of some of them. On the other hand, carnivorous birds (predatory birds and owls) shed oocysts-sporocysts of *Sarcocystis* type (Rommel and Krampitz 1975, Černá 1976, Tadros and Laarman 1976, Štochlová and Černá 1978). Some of these species utilize small mammals as the intermediate hosts (Rommel and Krampitz 1975, 1978, Tadros and Laarman 1976, Černá 1976, 1977, Černá and Loučková 1976). Since the food spectrum of carnivorous birds, particularly of the predatory ones, was reported to involve different passerine and other birds, we considered the possibility of the bird-bird relation in the life cycle of *Sarcocystis*. Table 1 shows that the oocysts-sporocysts from the intestine of *Accipiter gentilis* initiated an infection in *Serinus canaria*, whereas morphologically different sporocysts from the intestine of *Accipiter nisus* did not. Box and Smith (1982) and Box et al. (1984) in their experiments with opossums and birds found that, in contrast to a considerable intermediate host specificity of *Sarcocystis* observed in mammals, the intermediate host spectrum in birds is much wider. *Sarcocystis falcatula*, the definitive host of which, according to the above authors, is the opossum (*Didelphis virginiana*), accomplishes its asexual reproduction in different birds of the orders *Passeriformes*, *Psittaciformes* and *Columbiformes*. We assume therefore that the *Sarcocystis* species from goshawks, which in our experiment realized its asexual cycle in the canary, might occur in different *Passeriformes* serving as the food of goshawks. It is also possible that the elongate, roll-shaped sarcocysts with a thin wall and minute cystozoites found by Pecka (1983) in *Garrulus glandarius* (Corvidae) (see Černá 1984) may belong to the species identified by us.

Although the species studied seems to occur in various *Passeriformes* as intermediate hosts, it is difficult to identify it with any of the hitherto published *Sarcocystis* species from *Passeriformes*. We considered *S. corderoi* Vogelsang, 1929 reported from *Passer domesticus* or *S. turdi* Brumpt, 1913 from *Turdus merula* (see Levine and Tadros 1980), but no data about the morphology of coccidia found in these hosts are available. Since in no case the canary has been reported as the host of *Sarcocystis*, we decided to give the species involving canary-goshawk relation a new name, *Sarcocystis accipitris* sp. n. after its definitive host, *Accipiter gentilis*. Its characteristics are given below.

Definitive host: *Accipiter gentilis*
Intermediate host: *Serinus canaria* and probably other *Passeriformes*
Oocyst size: 21—25 × 15—17 μm
Sporocyst size: 15—17 × 13—15 μm
Sarcocysts in the intermediate host: thin, elongate, with a thin wall (less than 1 μm)
Cystozoites: very small, crescent-shaped, 5—7 × 1.5—2 μm

ЦИКЛ РАЗВИТИЯ *SARCOCYSTIS COCCIDIA* В ОТНОШЕНИИ ПТИЦА—ПТИЦА С ОПИСАНИЕМ *SARCOCYSTIS ACCIPITRIS* SP. N.

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Резюме. Описан цикл развития кокцидии рода *Sarcocystis* в отношении птица—птица. Ястреб-тетеревятник (*Accipiter gentilis*) служил как дефинитивный хозяин и выделял ооцисты размером 21—25 + 15—17 мкм, с релативно широкими спороцистами немного суживающимися в концу, размером 15—17 + 13—15 мкм. Канарейка (*Serinus canaria*) служила в экспериментальных условиях как промежуточный хозяин. Предполагается, что другие виды *Passeriformes*, которые источником питания для ястреба-тетеревятника, могут служить как промежуточный хозяин в природе. В суживающихся в концу и вытянутых (длиной в продольных сечениях 600—900 μ*N*, шириной в поперечных сечениях 21—42 × 19—30 мкм) саркоцистах внутри промежуточного хозяина была обнаружена очень тонкая стена (< 1 мкм). Цистозоиты очень маленькие, С-образные, размером 5—7 × 1,5—2 мкм. Вид назвали *Sarcocystis accipitris* sp. n. по его дефинитивном хозяину.

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J. Jíra, B. Rosický: Imunodiagnostika a epidemiologie toxoplasmosy. (Immunodiagnostics and Epidemiology of Toxoplasmosis.)

Publ. House Academia, Praha 1983, 262 pp., 8 Figs., 58 Tables. Price 48 Kčs.

The literature on toxoplasmosis is now very abundant and is increasing every year. The book under review, owing to its conception, is therefore very welcome. It introduces anyone interested in this field into the immunodiagnostics and epidemiology of toxoplasmosis and other related problems, some facts of which may be otherwise difficult to find. The wealth of data is not surprising since the book was written by learned authors. Dr. Jíra published some years ago, together with Dr. V. KOZOJED, a bibliography on toxoplasmosis of the years 1908—1967 and 1968 to 1975 (Fischer, Stuttgart 1970 and 1983).

The contents of the present book can be best characterized by the titles of the chapters: Biology of the Parasite, Methods of Immunological Detection of Toxoplasma Infections, Parasite-Host Relationship in Toxoplasmosis, Toxoplasmosis and the Phenomenon of Natural Focality, Feline Hosts and Toxoplasmosis, Toxoplasmosis in Feral Sphere, Toxoplasmosis in Domestic Sphere, Toxoplasmosis in Human Sphere. The book is concluded by Czech, Russian and English summaries and a list of literature from 1976—1979 (1981). As is evident from this account, the title of the book is somewhat modest — the contents include also a chapter on the biology of *Toxoplasma gondii* with informative paragraphs on cytology and taxonomy.

The number of copies printed is rather "bibliophilic", only 800, so it may be supposed that another edition will follow. For this event some changes are suggested. In the epidemiologic part the information contained in the text could be made more informative by including more tables or graphs. If the titres of specific positivity given by individual authors were supplemented, a better evaluation of the results by the reader would be possible. If the technical circumstances are favorable, full citations of the literature would be more informative.

This book is unquestionably a valuable aid to all specialists in this field and will be of good service on their shelves.

Dr. J. Chalupský

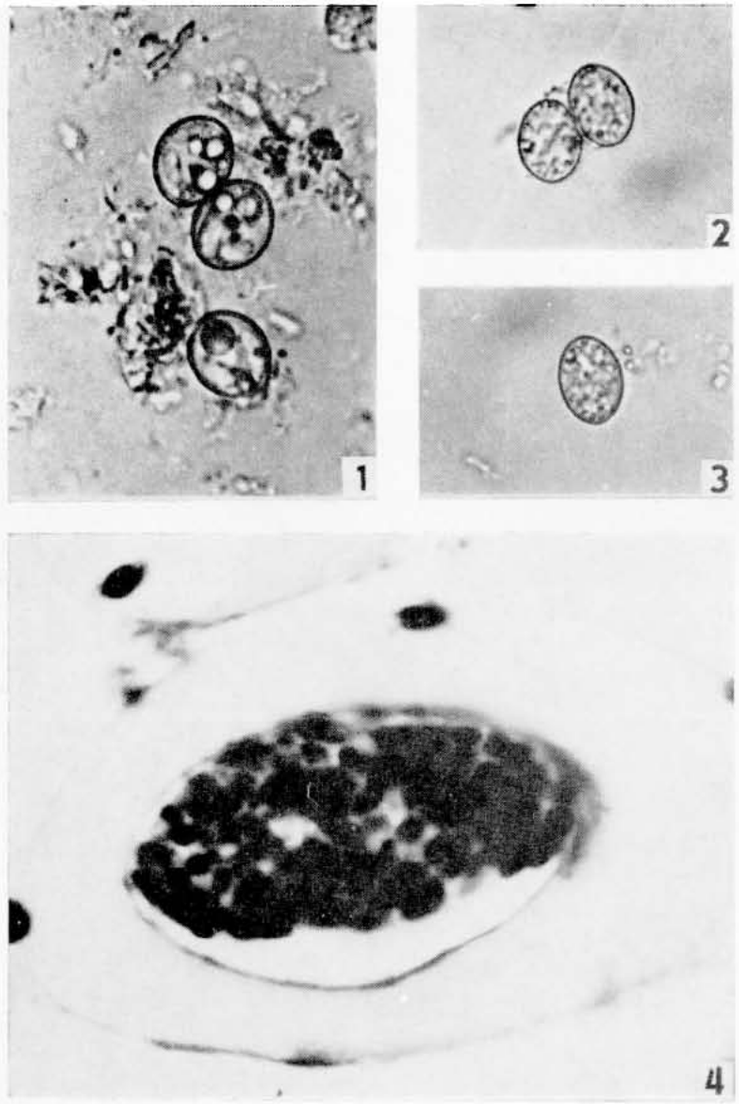

Fig. 1. Oocyst and sporocyst of *Sarcocystis accipitris* sp. n. from the feaces of *Accipiter gentilis* (× 800).
Fig. 2—3. Oocyst (Fig. 2) and sporocyst (Fig. 3) of *Sarcocystis* sp. from the feaces of *Accipiter nisus* (× 800).
Fig. 4. Thin-walled sarcocyst of *S. accipitris* sp. n. Transverse section. Harris's hematoxylin (× 2 000).

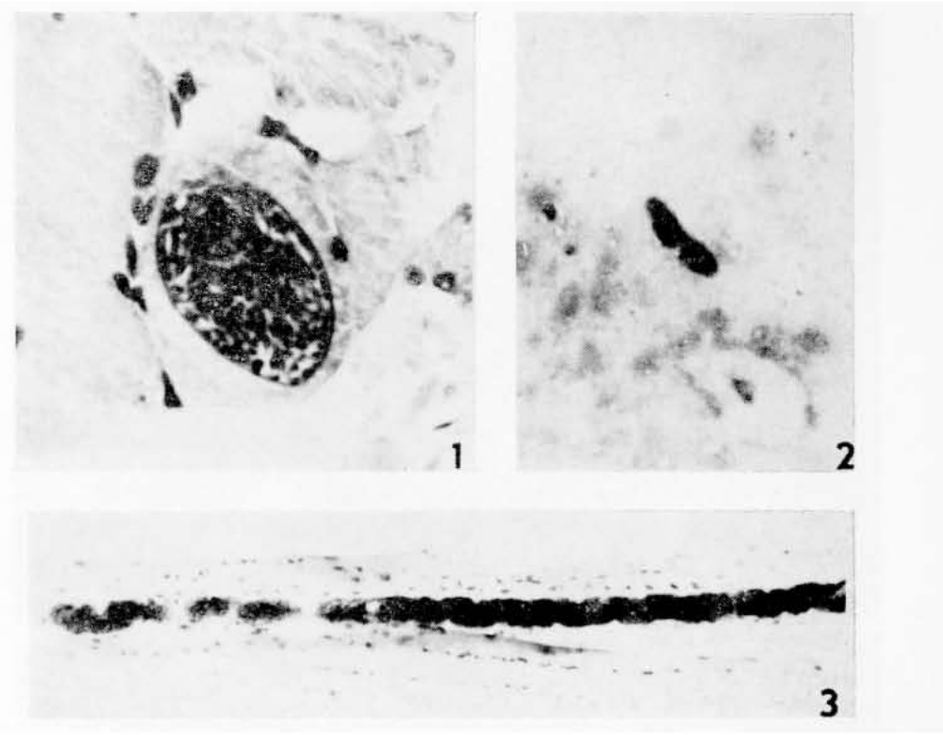

Fig. 1—3. Muscles stages of *S. accipitris* sp. n. from *Serinus canaria*.
1: Transverse section through the sarcocyst. Harris's hematoxylin (× 900).
2: Cystozoit. Giemsa (× 2 000).
3: Longitudinal section through the sarcocyst. Harris's hematoxylin (× 200).